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Note that this section is based on AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, Sixth Edition* and allowable stress design.

10.2 Sign Supports

This series of articles replaces previous office documents for overhead sign truss design criteria.

In the following articles [AASHTO-Sign article, table, or figure] refers to *AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, Sixth Edition, 2013.* The office generally follows the AASHTO sign support specifications but modifies some provisions based on experience and local fabricating practice.

10.2.1 General

Sign structures for state highways usually are designed by the Office of Bridges and Structures rather than by consulting engineers. As much as possible, the office has developed standard plans, which then can be used by the Office of Traffic and Safety for typical projects. The standards have included both aluminum and steel components but, because of fatigue concerns, the office presently is moving toward all-steel structures. Present standard plans for cantilever sign supports, however, utilize aluminum cantilever trusses with steel supports.

The office presently designs the following types of sign structures:

- Overhead bridge sign trusses (OBS SS SOST-01-11 to SOST-20-11 which includes trusses for dynamic message signs (DMS)),
- Overhead cantilever sign trusses (OBS SS 5557-5561),
- Steel roadside DMS supports, and
- Bridge-mounted sign supports.

When signs on existing structures are updated, the Office of Traffic and Safety submits the changes for review by the Office of Bridges and Structures.

10.2.1.1 Policy overview

The design of sign support structures has changed rapidly in recent years for several reasons. In the 1994 AASHTO sign specifications there was little information on fatigue design other than reference to the AASHTO Standard Specifications for Highway Bridges, but since 2001 the sign specifications have had detailed fatigue requirements that may control the design. The 2001 sign specifications required detailed fatigue design only for overhead cantilever sign structures, but then the 2009 sign specifications extended those requirements to overhead bridge sign structures. The detailed fatigue requirements are more favorable for steel than for aluminum, allowing significantly larger stresses for steel connections.

Recent increases in required lettering sizes necessitate larger signs. In 2000 the office designed standard overhead sign structures for signs 10 or 12 feet tall, but at this time there sometimes is need to design for signs over 20 feet tall. Another trend that has affected design is the state program to construct a network of dynamic message signs (DMSs) throughout the state supported on overhead bridge sign trusses, as well as on steel roadside supports.

The office typically designs overhead bridge sign trusses in a four-chord box truss configuration with galvanized steel pipe or hollow structural sections. The trusses generally are sized for center-to-center chord spacings of 5 feet horizontal by 6 feet vertical. The overhead trusses are based on a Warren configuration on all four sides, with panel points at 5 feet along the length and an internal diagonal at each set of panel points. For ease of shipping and, in the case of steel, for ease of galvanizing, the trusses are designed with separate sections 20 to 40 feet long bolted together at chord splices.

Researchers at the Bridge Engineering Center at Iowa State University have tested a corroded and damaged galvanized steel overhead bridge sign truss, and researchers at Purdue University have tested two damaged aluminum overhead bridge sign trusses [BDM 10.2.1.5]. All of the testing has indicated that the Warren, four-chord configuration is robust. Typical trusses will not deflect excessively or fail to carry design loads, even with noticeable corrosion or fatigue damage to one chord.

During reconstruction of I-235 in Des Moines the office designed arch-top aluminum overhead bridge sign trusses with a Pratt configuration on the sides and a Warren configuration on the top and bottom. Due to the arch-top configuration, web members on the sides of the trusses were more slender than usual. Because of concern that the individual slender members could be subject to vortex shedding and fatigue damage, the office has discontinued the configuration.

Recent sign truss inspections have indicated that aluminum overhead bridge sign trusses supporting DMSs have a larger percentage of cracked connection welds than trusses supporting signs. Many of the fractures have been at redundant internal diagonals. Examination of the fractures suggests poor fabrication rather than fatigue.

Considering the changes in the AASHTO sign specifications, the need for larger signs, the need to design for fatigue, and the apparently poor performance of trusses carrying DMSs, the office is modifying design policies. With few exceptions, standards for 50 to 130 feet galvanized steel overhead bridge sign trusses (OBS SS SOST-01-11 to SOST-20-11) are now used for both static signs and dynamic message signs. Standards for aluminum overhead cantilever trusses with galvanized steel end posts (OBS SS 5557-5561) also may be used for static signs, but the office intends to replace these current standards with all-galvanized-steel standards. Due to vibration and fatigue concerns DMS placed in an overhead position must be supported on all-galvanized-steel bridge sign trusses with galvanized steel supports unless permission is granted by the Chief Structural Engineer to place a DMS on an all-galvanized-steel cantilever truss with a galvanized steel end post. To meet AASHTO sign specification fatigue resistance and ease of fabrication, those DMS-supporting structures are to be fabricated with gusset and slotted pipe connections.

The office requires a vertical clearance of 17.50 feet (5.340 m) below signs, which is one foot (300 mm) more than the clearance for typical overpasses. The office prefers that static signs and DMSs be centered vertically on a sign support structure so that wind will not cause a significant torsional moment about a horizontal axis.

The office standard sign structure plans show foundations for overhead bridge sign trusses consisting of a foundation wall on a spread footing and foundations for overhead cantilever trusses consisting of a pedestal (identified as shaft on plans) on a spread footing. For poor soil conditions, locations above utility lines, and other special site conditions the office prefers steel H-piles with footings instead of drilled shafts. Drilled shaft foundations may be used only with permission of the supervising Section Leader.

Due to potential fatigue damage from traffic vibrations, overhead cantilever sign structures shall not be located on highway bridges. The office also strongly recommends that overhead bridge sign structures not be located on highway bridges but, if a sign structure must be located on a bridge, the structure shall be located at or very near a pier.

Although the office no longer needs to add outriggers to sign trusses for night-time illumination of signs, the office does provide runways and ladders for service of overhead DMSs. These service aids need to be considered in the loading of the DMS support structure, and they need to be planned with respect to Occupational Safety and Health Administration (OSHA) rules and security needs.

The office has made limited use of bridge mounted sign supports. With recent concerns about epoxy anchors it has been difficult to design the anchorages to typical curbs.

10.2.1.2 Design information

The Office of Traffic and Safety determines the need for signing on the state highway system and establishes sign sizes and locations. When standard plans and specifications for sign supports do not cover given situations the Office of Bridges and Structures either approves standard plans with exceptions or specially designs the supports. For approving new signs on existing overhead structures the office has a relatively simple checking procedure covered in subsequent articles [BDM 10.2.4.2 – 10.2.4.5].

For use of standard spread footings for overhead sign supports, the soil is assumed to have an allowable pressure of 2000 psf (96 kPa) or greater. Generally the locations of spread footings are within the prepared base for the highway where soils have reasonable capacity, and no specific soil information is needed. However, in the following cases the designer shall consult with the Soils Design Section:

- Spread footings need to be placed where there is uncertainty regarding soil capacity (e.g., at a location in or near a river floodplain),
- Spread footings need to be located farther than usual from the roadway,
- Footings need to be placed on piles, or
- Structures need to be placed on drilled shafts.

10.2.1.3 Definitions

Reserved

10.2.1.4 Abbreviations and notation [AASHTO-Sign 3.8.3, 3.8.4, 3.8.6, 5.3, 6.2]

C_d, drag coefficient [AASHTO-Sign 3.8.6]

DMS, dynamic message sign, also called changeable message sign (CMS) or variable message sign (VMS)
I_r, wind importance factor [AASHTO-Sign 3.8.3]
k, effective length factor for a compression member [AASHTO-Sign 5.3, 6.2]
K_z, height and exposure factor [AASHTO-Sign 3.8.4]
L, unbraced length of a compression member [BDM 10.2.4.1.1]; span length [BDM 10.2.4.1.2]
OSHA, Occupational Safety and Health Administration
r, radius of gyration [AASHTO-Sign 5.3, 6.2]
Δ_{Beam}, deflection of a beam with the moment of inertia of the truss chord configuration
Δ_{DL}, dead load deflection at midspan
Δ_{Truss}, approximate deflection of the truss

10.2.1.5 References

Aluminum Association (AA). *Aluminum Design Manual.* Washington: The Aluminum Association, Inc., 2000.

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Letchford, C.W. "Wind loads on rectangular signboards and hoardings," *Journal of Wind Engineering and Industrial Aerodynamics*, Vol. 89, 2001, pp 135-151.

New York State Department of Transportation (NYSDOT). *Overhead Sign Structure Design Manual.* Albany: NYSDOT, 2008.

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10.2.2 Loads

10.2.2.1 Dead [AASHTO-Sign 3.5]

The dead load shall include all permanent parts of the structure; all attachments such as signs, runways, and ladders; and temporary dead loads during maintenance [AASHTO-Sign 3.5].

Weight of a typical aluminum sign panel with back framing, not exceeding 14.75 feet (4.500 m) tall may be taken as 5 psf (240 Pa). The designer shall determine the unit weight of taller aluminum signs with back framing and signs of other materials with framing.

The designer shall determine and use the actual weight of dynamic message signs (DMSs) and other special sign types.

The designer should note that a runway for service of a DMS has significant weight. The runway may weigh nearly as much per foot of length as a DMS.

10.2.2.2 Live [AASHTO-Sign 3.6]

For the typical unlighted overhead sign truss and cantilever sign truss there is no runway or platform, and therefore no live load.

In cases where a runway or platform is attached to an overhead sign truss, a single 500 lb (2200 N) load shall be applied to each runway or platform member, distributed transversely over 2 feet (600 mm) [AASHTO-Sign 3.6]. The live load also shall be applied for design of the connections to the overhead sign truss structure but need not be applied to the truss structure itself because the design group load combinations [BDM 10.2.3] will ensure adequate strength for the temporary live load.

10.2.2.3 Ice [AASHTO-Sign 3.7]

Ice load of 3 psf (145 Pa) [AASHTO-Sign 3.7] shall be applied to the following:

- The entire surface of each member and gusset plate in a sign structure,
- One side of ordinary signs,
- The top, ends, and one face of a DMS,
- The nominal plan area (neglecting openings) of a runway grate, and
- The entire surface of runway rails, runway supports, and ladder members.

10.2.2.4 Wind [AASHTO-Sign 3.8.3, 3.8.6, 3.9.3]

Design wind pressure in the AASHTO sign specifications is determined as the product of several factors. In most cases the basic height and exposure factor, K_z = 1.00 will suffice, but when 20-foot tall signs are placed on an overhead sign truss or a sign truss is located near or on a highway bridge, the designer needs to check the maximum sign elevation with respect to the surrounding ground or water level. The height and exposure factor may need to be increased, which will result in a design wind pressure increase.

For structures on the state highway system the wind importance factor, I_r, shall be taken as 1.00 [AASHTO-Sign 3.8.3].

Design wind pressure also is dependent on a drag coefficient, C_d. The AASHTO sign specifications follow traditional coefficients (that may be increased in the future to be consistent with those in the ASCE/SEI-7 standard [BDM 10.2.1.5]). At this time the office uses the following AASHTO-specified drag coefficients [AASHTO-Sign 3.8.6]:

- Typical signs with aspect ratios of 1.0 to 5.0: 1.2
- DMSs: 1.7
- Unshielded tubular sign structure members: 1.2

For typical structures with the weighted-mean average of all sign centroid heights less than 32.8 feet (10.000 m) above the roadway the office uses the following wind pressures determined from a basic wind speed of 90 mph (40 m/s) associated with a 50-year recurrence interval:

- Signs: 30 psf (1436 Pa)
- DMSs: 40 psf (1915 Pa)
- Unshielded sign structure members: 30 psf (1436 Pa)

Structures carrying 20-foot (6.100-m) tall signs, structures with gusset plate connections, and structures elevated above surrounding ground or water level usually will need to be designed for larger wind loads.

Member shielding in truss frameworks is interrelated with the drag coefficient. In applying the 30 psf (1440 Pa) to truss members the office has the following policies, which generally give conservative results.

- For wind normal to a truss [AASHTO-Sign 3.9.3], consider members facing the wind on both the front and back of the truss to be loaded. Consider members between front and back that would be hidden in an elevation view and members parallel with the wind to be shielded from wind load.
- Apply normal wind to the sign structure from the back, considering all members in the back face to be loaded and the members in the front face directly behind a sign or DMS to be shielded.
- For wind transverse [AASHTO-Sign 3.9.3], consider the horizontal and vertical members at 5-foot (1.524-m) intervals to be loaded and all horizontal and vertical diagonals behind those members to be shielded.

In lieu of applying the wind from multiple directions, the designer may use the two load cases for simultaneous normal and transverse wind loads given in the AASHTO sign specifications [AASHTO-Sign 3.9.3]. The two load cases apply to the typical sign support with signs in approximately one plane but do not apply to unusual structures with arms in two or more planes.

10.2.2.5 Fatigue [AASHTO-Sign 11.6, 11.7.1, 11.9]

Design for fatigue in the AASHTO specifications involves use of fatigue design loads to determine nominal stress ranges at member connections in the structure and ensuring that those stresses are less than the appropriate fatigue limits for the connection details [AASHTO-Sign 11.9].

Three types of equivalent static loads are required for overhead structures:

- Galloping [AASHTO-Sign 11.7.1.1],
- Natural wind gust [AASHTO-Sign 11.7.1.2], and
- Truck-induced gust [AASHTO-Sign 11.7.1.3].

All three loads apply to overhead cantilevered structures, but only natural wind gust and truck-induced gust loads apply to overhead bridge sign structures.

Each of the loads is multiplied by the fatigue importance factor, I_f [AASHTO-Sign 11.6]. For structures on the state highway system the designer shall take the fatigue importance factor as 1.00.

The natural wind gust and truck gust loads also depend on the drag coefficient. The designer shall select the drag coefficient and apply shielding using the wind load guidelines in the article above [BDM 10.2.2.4].

In determining the nominal stress ranges at a connection, the designer shall add the axial stresses to the combined bending stresses, if the connection is assumed to be rigid. The designer need not separate tension from compression stresses because stresses usually reverse with opposite wind direction or oscillation of the structure.

Under the fatigue design loading and fatigue resistances in the AASHTO sign specifications, the design of typical overhead structures will be at least partially controlled by fatigue rather than by structural design.

10.2.3 Group loads and application to signs and supports [AASHTO-Sign 3.4]

The AASHTO sign specifications identify four group load combinations to be used in design [AASHTO-Sign 3.4]. The first three combinations are for structural design. Because Group Loads II and III are to be used with a 133% allowable stress it may be easiest to multiply those two load combinations by 0.75 during analysis so that the results of all three load combinations can be compared directly at 100% allowable stress.

Live load is not included in any of the group load combinations but is to be considered locally for service facilities such as runways or platforms [BDM 10.2.2.2].

Group Load IV is for fatigue design and is discussed above [BDM 10.2.2.5].

10.2.4 Analysis and design [AASHTO-Sign 4.4, 4.5, 10.5]

Analysis of sign support structures shall be performed with the assumption that members and components behave elastically [AASHTO-Sign 4.5]. Design of metal members and reinforced concrete components of sign supports shall follow the allowable stress design (ASD) method [AASHTO-Sign 4.4].

The designer should use the following assumptions for typical truss connections.

- Welded tube to tube or pipe to pipe, chord to web member connections are rigid with respect to both axes.
- Welded gusset plate, chord to web member connections are rigid in the plane of the gusset and pinned out of plane.
- Bolted gusset plate, chord to web member bearing connections are pinned with respect to both axes.
- Bolted gusset plate, chord to web member fully tightened connections are rigid in the plane of the gusset and pinned out of plane.
- Shop welded, field bolted splice plate, chord to chord connections are rigid with respect to both axes.
- Shop welded, field bolted base plate to anchor bolt connections are rigid with respect to both axes.

The designer may utilize commercial finite element software such as STAAD.Pro to analyze and design sign structures. The software normally will consider all members to be rigidly connected about both axes and thus automatically will determine secondary bending stresses in trussed portions of the structure. Where the rigid connections are not appropriate the designer has the option of specifying releases to simulate pinned connections.

Usually the software also will consider all members fully braced at each end, and that assumption will need to be corrected for compression and bending in posts composed of more than one finite element member and possibly for other conditions in the structure. In the typical overhead bridge sign truss, upper U-bolt connections between post and truss chord can carry only tension, and the designer needs to model the connections carefully. The designer shall verify the finite element analysis and design computations for critical members by hand computations.

For an overhead bridge sign truss the midspan deflection under dead and ice load shall not exceed 1/150 of the span length [AASHTO-Sign 10.4.1]. For hand computations the truss deflection may be determined as for beams but with an increase of 20% to account for the flexibility of truss web members.

$$\Delta_{Truss} = 1.2\Delta_{Beam}$$

Where:

Δ_{Truss} = approximate deflection of the truss
Δ_{Beam} = deflection of a beam with the moment of inertia of the truss chord configuration

Camber of overhead bridge sign trusses shall be determined from the following equation [AASHTO-Sign 10.5]:

$$Camber = \Delta_{DL} + \frac{L}{1000}$$

Where:
Δ_{DL} = dead load deflection at midspan
L = span length

10.2.4.1 New structures

10.2.4.1.1 Steel [AASHTO-Sign Section 5, 5.4, 5.9, 5.10, 5.11, 5.12, 5.14.1, 10.4.3.1]

The designer shall use the steel design provisions in the AASHTO sign specifications [AASHTO-Sign Section 5] wherever applicable. For unusual conditions where the design specifications do not apply, the designer shall follow other specifications referenced by the sign specifications. If no specifications are referenced, American Institute of Steel Construction's *Steel Construction Manual* or *Hollow Structural Sections Connection Manual* [BDM 10.2.1.5] often will have more appropriate information than the AASHTO Standard Specifications for Highway Bridges.

Unless otherwise noted on the plans, steel shall meet the following material requirements.

- Shapes and plates: ASTM A36 (except that minor parts approved by the engineer may be ASTM A575 Grade M1020)
- Pipe: ASTM A53 Grade B, Type E or S; or API 5L Grade B
- Round or rectangular hollow structural sections (HSS): ASTM A500 Grade B
- Galvanized high strength bolts: ASTM A325, Type 1, Class 2A
- Galvanized nuts: ASTM A563, Grade DH, Class 2B
- Galvanized washers: ASTM F436, Type 1
- Anchor bolts (or rods): ASTM F1554 Grade 55, S1*, Class 2A or ASTM F1554 Grade 105, S5** Class 2A [OM IM 453.08]

* S1 = supplementary requirement for chemical composition to assure weldability
** S5 = supplementary requirement for Charpy impact

Because manufacturers now can reliably produce pipe and HSS with dimensions at or near the lower limit of the tolerance range, pipe and HSS section design properties have been reduced to those listed in *Manual of Steel Construction, Fourteenth Edition*; however, software may not be corrected for the changes. When using software for analysis and design the designer needs to ensure that the software is using the latest pipe and HSS section properties or compensate for the differences between old and new properties.

Minimum thickness for steel material shall be 0.1875 inches (4.76 mm) for main members and 0.125 inches (3.17 mm) for web and secondary members [AASHTO-Sign 5.14.1].

All steel material with a thickness greater than 0.500 inches (13 mm) in main load carrying tension members shall meet current Charpy V-notch impact requirements [AASHTO-Sign 5.4, AASHTO-I 10.3.3]. The portions of the structure required to meet impact requirements shall be designated on the plans and noted for Temperature Zone 2. The designer shall discuss any need for Charpy V-notch impact requirements with the supervising Section Leader.

The office prefers that fillet weld size be limited to 5/16 inch (8 mm), the largest weld that can be made in a single pass.

Bolts for chord splices and other truss member connections shall be ASTM A325 galvanized high strength steel bolts [IDOT SS 4153.06, B, 1] installed by the turn-of-the-nut method [IDOT SS 2408.03, S, 5]. Preferred bolt size is 7/8 inch (22 mm).

U-bolts for attachment of aluminum signs, aluminum DMS cabinets, and other aluminum parts shall be stainless steel [IDOT SS 4187.01.C.1]. U-bolts for connection of galvanized steel truss components, galvanized steel runways, and other galvanized steel parts may be stainless steel or galvanized steel [IDOT SS 4187.01.C.2].

For steel truss members in tension, L/r shall not exceed 240 [AASHTO-Sign 5.9.2]. Overly slender members may vibrate individually [AASHTO-Sign 10.4.3.1].

Office policy is to use the length between working points with the following effective length factors (k-factors) for compression members:

- k = 1.0 for truss chords and web members,
- k = 1.8, minimum, for end posts in overhead bridge sign truss structures for the direction in which they behave as frame (rather than truss) members, and
- k = 2.1 for posts in overhead cantilever truss structures.

For steel truss members in compression, kL/r shall not exceed 140 [AASHTO-Sign 5.10.1].

All steel sign support components shall be galvanized after fabrication. The galvanizing is intended to include both the exterior and interior of tubular members. Because of explosive pressures generated in sealed spaces during galvanizing and restricted flow of molten zinc after hot dipping of a component, vent and drain holes are required in some cases. The designer should anticipate the need for and locations for holes and design accordingly.

Steel overhead sign trusses do not require a damping device.

10.2.4.1.2 Aluminum [AASHTO-Sign Section 6, Table 6-2, 6.4.3.1, 6.4.4.2, 6.8.1, 6.9, 10.4.3, 10.4.3.1, Table B-9]

Aluminum box truss components are assembled from tubes with continuous chords connected with short web members. Except where gussets are used, the web diagonals and struts are cut to length with fish-mouth ends, which then are fillet welded to the continuous members. The diagonal and strut connections are gapped so that there is no overlap between adjacent web members. Usually the gap created at the surface of chords by aligning centerlines of all intersecting members at a point is sufficient, but occasionally it may be necessary to realign web members. If the final alignment is more than 2 inches (50 mm) from the centerline alignment at a point, the realignment shall be considered in the analysis.

For ease of fabrication internal diagonals usually are offset from panel points. Because internal diagonals are redundant and lightly stressed the offset need not be considered in design.

Because it is difficult to weld and inspect connections between members that intersect at small angles, the angle between any diagonal and chord shall be 35 degrees or more. Although the lower limit for end-welded tubular connections is taken as 30 degrees by some authorities, the office has set the higher limit based on the advice of aluminum sign support fabricators.

The designer shall use the aluminum design provisions in the AASHTO sign specifications [AASHTO-Sign Section 6] wherever applicable. For unusual conditions where the specifications do not apply, the designer shall follow other specifications referenced by the sign specifications. If no specifications are referenced, Aluminum Association’s *Aluminum Design Manual* [BDM 10.2.1.5] often will have more appropriate information than the AASHTO Standard Specifications for Highway Bridges.

Extruded tube, structural shapes, and plate for aluminum sign trusses shall be Alloy 6061-T6.

Minimum thickness for aluminum material shall be 0.125 inches (3.17 mm) [AASHTO-Sign 6.8.1].

Because welding removes beneficial effects of heat-treating and cold working, allowable stresses need to be reduced for zones within one inch (25 mm) of a weld as required in the AASHTO sign specifications [AASHTO-Sign 6.5]. Because the reductions are difficult to apply as intended by the specifications, the designer should consult tables specifically for Alloy 6061-T6 [AASHTO-Sign Table B.6-4 (B.6-3)].

The designer also shall consider the locations of the welded zones in a member with respect to potential buckling or bending collapse mechanisms. The zones weakened by welding will behave as hinges under overload and lead to early collapse unless the allowable stresses are correctly evaluated with respect to member behavior.

Welding shall conform to *Structural Welding Code—Aluminum, AWS D1.2/D1.2M: 2008* [AASHTO-Sign 6.9 and BDM 10.2.1.5]. For the typical sign trusses, workmanship shall be Class I. The office modifies the welding code specifications as follows.

- The office prefers that fillet weld size be limited to 5/16 inch (8 mm), the largest weld that can be made in a single pass.
- Aluminum filler alloy ER5356 or ER5556 shall be used [IDOT SS 4187.01, A, 7]. Only microscopically clean welding wire (those which have been shaved after drawing) should be used, and spools of wire remaining at the end of the day’s production should be sealed in polyethylene bags. Welding wire in drive rolls and gun not so protected should be discarded. With ER5356 or ER5556 electrodes allowable design stresses for welded zones do not need to be additionally reduced for member thicknesses above 0.375 inches (9.5 mm) [AASHTO-Sign Table 6.4-2].
- Tubes should be milled to the required radii with the maximum gap at any point not greater than 1/16 inch (1.6 mm). Forced fits must be avoided, and only downhand welding is allowed.
- All areas to be welded shall be brushed with stainless steel brushes immediately prior to welding. All aluminum welding shall be performed by the gas metal arc welding (GMAW) process. Only the stringer bead technique shall be used. Interpass temperature shall not exceed 200 degrees Fahrenheit (93 degrees Celsius). All initial root passes shall not exceed 5/16 inch (8 mm) and must penetrate the root. The convexity of a fillet weld shall not exceed 1/16 inch (2 mm). All weld craters must be eliminated, and wherever possible welds should carry through tight areas without stopping.
- Tack weld ends shall be filled and shall not terminate in craters. If a tack weld is cracked, the crack shall be removed before welding begins.

Galvanized high strength A325 or stainless steel bolts [IDOT SS 4187.01.C.1] shall be used in chord splices. Preferred size is 7/8-inch (22-mm).

U-bolts for attachment of aluminum signs, aluminum DMS cabinets, and other aluminum parts shall be stainless steel [IDOT SS 4187.01.C.1].

Slender aluminum truss members may vibrate individually during uniform wind conditions and eventually suffer fatigue damage. Based on satisfactory performance of Iowa DOT aluminum sign trusses in service, the office prefers that the slenderness of all diagonals and struts not exceed an L/r of 150. The limit of 150 is more conservative than the recommended slenderness limit for tension members in the AASHTO sign specifications [AASHTO-Sign 6.4.3.1, 10.4.3.1].

Office policy is to use the length between working points with the following effective length factors (k-factors) for compression members:

- k = 1.0 for truss chords and web members,
- k = 1.8, minimum, for end posts in overhead bridge sign truss structures for the direction in which they behave as frame (rather than truss) members, and
- k = 2.1 for posts in overhead cantilever truss structures.

For truss members in compression, the slenderness limit, kL/r, should not exceed 120 [AASHTO-Sign 6.4.4.2].

To avoid damaging vibrations of an aluminum overhead truss when sign panels are not attached, a damping device shall be provided at the center of the truss [AASHTO-Sign 10.4.3]. The damping device shall be a 31-pound (14 kg) stockbridge type (Alcoa Aluminum 1708-17.1) or approved equal.

10.2.4.2 Existing structures

When sign areas are to be changed on existing overhead bridge sign trusses, overhead cantilever sign trusses, or bridge-mounted supports during signing updates, the office will review the changes based on the following documents from the Office of Traffic and Safety:

- A copy of the original design plans,
- The sign dimensions for all signs that will remain on the truss, and
- The dimensions of the new signs being installed on the trusses.

There are three possible results of the review:

- Existing sign supports are acceptable with the new signs,
- Signs need to be reduced in size, or
- Existing sign supports need to be replaced.

10.2.4.3 Overhead bridge sign truss review

The review of an overhead bridge sign truss shall be based on the allowable sign area and wind load shown on the plans for the structure. If the new sign area is larger than the allowable sign area or the sign height is greater than the allowable sign height, the designer shall perform an approximate analysis.

For an approximate analysis, the designer shall assume the truss to be a simple span beam and the supports to be simple cantilevers. Place the wind loads on the allowable sign area to determine the maximum moment and shear in the truss and the maximum axial load and moment at the base of the posts. Compare these quantities to those determined using the new sign area and location. If the moments, shear, and axial load are no more than 10 percent greater than those calculated for the allowable sign area, the new sign area may be approved.

If the sign height extends above the top chord or below the bottom chord of the truss more than 5.25 feet (1.600 m), the horizontal spacing of aluminum 6 x 3½ x ½-inch (152 x 89 x 12.7-mm) angles will need to be reduced from the 5-foot (1.520-m) maximum. If the sign height extends above the top chord or below the bottom chord of the truss by more than 6.5 feet (2.000 m) the horizontal spacing of steel 6 x 3½ x ½-inch (152 x 89 x 12.7-mm) angles will need to be reduced from the 5-foot (1.520-m) maximum. The designer will need to provide the new maximum spacing to the Office of Traffic and Safety for inclusion in their plan set. As an alternative to a reduced spacing for the sign-support angles, the designer may substitute a stronger section and U-bolt connection capable of resisting the design loads.

10.2.4.4 Overhead cantilever sign truss review

The review of an overhead cantilever sign truss shall be based on the sign area shown on the plans for the structure. If the new sign area is less than or equal to the sign area shown on the plan, the new sign area may be approved. If the new sign area is greater than the sign area shown on the plan, the sign area will be limited to the sizes shown in the tables below. Table 10.2.4.4-1 applies to larger structures, and Table 10.2.4.4-2 applies to smaller structures.

Table 10.2.4.4-1. Allowable sign area for larger overhead cantilever structures

Maximum cantilever length[(1)], feet (m)	Maximum sign height, feet (m)	Maximum sign area, ft^2 (m^2)
35.00 (10.660)	14.00 (4.260)	210 (19.5)
34.00 (10.360)	14.00 (4.260)	224 (20.8)

33.00 (10.060)	14.00 (4.260)	238 (22.1)

Table notes:

(1) See Figure 10.2.4.4.
(2) Steel pipe end post 22- or 24-inch diameter by 0.500 inch thick (559- or 610-mm by 12.7 mm)
(3) Maximum end post (truss) height 27.00 feet (8.230 m). See Figure 10.2.4.4.
(4) Aluminum truss chords 5½ x 5/16 inches (139 x 7.9 mm)
(5) Aluminum web members 2½ x ¼ inches, 2¼ x 3/16 inches, 2 x 3/16 inches, and 2 x ¼ inches (63 x 6.3 mm, 57 x 4.7 mm, 50 x 4.7 mm, and 50 x 6.3 mm)

Table 10.2.4.4-2. Allowable sign area for smaller overhead cantilever structures

Maximum cantilever length(1), feet (m)	**Maximum sign height, feet (m)**	**Maximum sign area, ft^2 (m^2)**
33.00 (10.060)	10.00 (3.050)	150 (13.9)
30.00 (9.100)	11.00 (3.350)	176 (16.4)
27.50 (8.380)	12.00 (3.650)	192 (17.8)

Table notes:

(1) See Figure 10.2.4.4.
(2) Steel pipe end post 18-inch diameter by 0.500 inch thick (457-mm by 12.7 mm)
(3) Maximum end post (truss) height 27.00 feet (8.230 m). See Figure 10.2.4.4.
(4) Aluminum truss chords 5½ x 5/16 inches (139 x 7.9 mm)
(5) Aluminum web members 2½ x3/16 inches, 1¾ x 3/16 inches, and 2 x 3/16 inches (63 x 4.7 mm, 44 x 4.7 mm, and 50 x 4.7 mm)

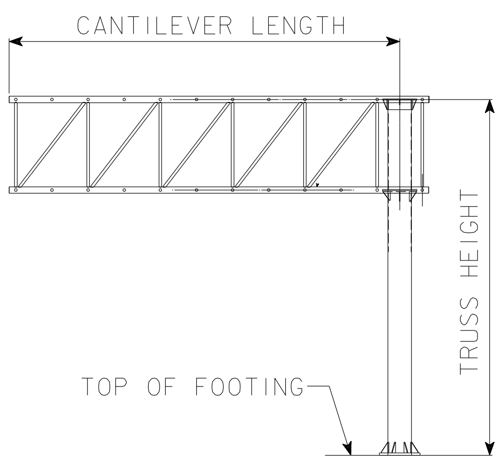

Figure 10.2.4.4. Overhead cantilever truss dimensions

10.2.4.5 Bridge-mounted sign support review

The designer shall base review of bridge-mounted sign supports on the limits in the original plan set. New signs will be allowed to extend one foot (300 mm) above the top of the existing sign members. This applies to all signs, including exit signs and hospital signs added to the top of existing sign configurations.

10.2.5 Detailing [AASHTO-Sign 6.11.1]

In order to prevent galvanic corrosion, contact between aluminum and dissimilar metals shall be avoided [AASHTO-Sign 6.11.1]. For typical sign support construction the office permits contact only between aluminum and stainless steel or galvanized steel.

Anchor bolts, nuts and washers shall be galvanized and of F1554, Grade 55, S1 or Grade 105, S5 [IDOT SS 4187.01.C.3]. Generally bolt size should match base plate thickness. Anchor bolt nuts shall be tightened by the turn-of-nut method, and the procedure shall be given on the plans. See the commentary for this article for the procedure [BDM C10.2.5].

Office policy does not permit the use of grout with anchor bolts, but allows space between base plate and top of foundation. To restrict entry to this space, the office uses a standard rodent guard (a wire mesh that wraps the base plate) detail. This detailing that excludes grout is intended to prevent corrosion.

For an overhead truss supporting a DMS details for the following are required:

- Electrical access,
- Walkway, and
- Ladder.

So that the contractor and construction personnel have erection standards, the designer shall include on the plans a list of tolerances for foundations and anchor bolts and for the completed structure. Typical tolerances are given in the commentary for this article [BDM C10.2.5].

10.2.6 Shop drawings

The fabricator shall submit shop drawings for review as required by the standard specifications [IDOT SS 2423.03, A, 1].

10.2.7 Structures and components

10.2.7.1 Overhead bridge sign trusses

Generally the office bases overhead bridge sign truss structures on a 5-foot length-module and provides standard plans for structures nominally 50 to 130 feet in length. Standard overhead trusses have center-to-center chord spacings of 5 feet horizontal by 6 feet vertical. The truss web members are arranged in a Warren pattern on all four sides, and internal diagonals are placed at each set of panel points along the truss. The truss is fabricated in 20- to 40-foot sections that are bolted together in the field. The latest standard plans make use of galvanized steel pipe (minimum yield strength of 35 ksi [241 MPa]) for the overhead truss and galvanized steel hollow structural sections (minimum steel yield strength of 42 ksi [290 MPa]) for the supports [OBS SS SOST-01-11 to SOST-07-11]. The standards allow for substitution of hollow structural sections for steel pipe.

Due to fabrication- or fatigue-related cracks in welds in overhead trusses supporting DMS cabinets, the office no longer places DMS cabinets on aluminum overhead trusses. The office currently permits only steel overhead trusses with gusset plate/slotted pipe connections to support DMS cabinets.

Overhead bridge sign structures generally should not be placed on highway bridges but, if a sign structure must be located on a bridge, it shall be located at or very near a pier.

10.2.7.2 Overhead cantilever sign trusses

The office usually configures overhead cantilever structures on a vertical, Pratt five-panel and horizontal, Warren ten-panel truss pattern. Because the truss configuration length is limited to 35 feet but does not vary much, the Pratt panel lengths typically are in the 6- to 7-foot range. Center-to-center chord spacings are 3 feet horizontal by 7 feet vertical. Internal diagonals are placed at all of the Pratt panel points. The latest standard plans make use of aluminum tubes for the overhead cantilever truss and galvanized steel pipe for the end post [OBS SS 5557 to 5561]. The office intends to replace these current standards with all-galvanized-steel standards.

DMS cabinets shall not be placed on overhead cantilever sign trusses unless approval is granted by the Chief Structural Engineer to place the DMS on an all-galvanized-steel cantilever truss with a galvanized steel end post.

Overhead cantilever sign trusses shall not be placed on highway bridges.

10.2.7.3 Roadside dynamic message sign support structures

The latest standard plans for roadside dynamic message sign support structures make use of a pair of galvanized steel pipe mast arms attached to a galvanized steel hollow structural section support post with a 30-foot maximum height [OBS SS RDMS-01-13 to RDMS-06-13].

10.2.7.4 Runways and ladders

Runways, ladders, other service aids, and their connections to sign structures need to be designed for dead load, live load, ice load, and wind load as indicated above [BDM 10.2.2]. Sign structures then need to be designed for dead, ice, and wind loads transmitted through the connections.

In addition to structural capacity, service aids need to be designed to meet Occupational Safety and Health Administration (OSHA) rules. The designer also must consider access restrictions to prevent unauthorized use.

10.2.7.5 Bridge-mounted sign supports

Reserved

10.2.7.6 Foundations [AASHTO-Sign 13.1, AASHTO-I 4.4.7.1.1.1, 4.11.4.1.5]

Generally the office prefers spread footings for support of overhead and roadside structures. The office standard sign structure plans show foundations for overhead bridge sign trusses consisting of a foundation wall on a spread footing and foundations for overhead cantilever trusses consisting of a pedestal on a spread footing. Spread footings for sign structures shall be designed according to the AASHTO Standard Specifications for Highway Bridges as required in the sign specifications [AASHTO-Sign 13.1], using either allowable stress design (ASD) or load factor design (LFD).

The bottom of a spread footing shall be placed at least 4 feet (1.219 m) below ground. Unless site soil information indicates otherwise, the designer may assume allowable bearing pressure to be 2000 psf (96 kPa). In order to prevent overturning of footings on soil, under ASD the eccentricity of loading shall not exceed one-sixth of the footing dimension [AASHTO-I 4.4.7.1.1.1]. Under LFD the eccentricity of factored loading shall not exceed one-fourth of the footing dimension [AASHTO-I 4.11.4.1.5]. When checking the bearing pressure and the eccentricity the designer should include the soil overburden.

For poor soil conditions, locations above utility lines, and other special site conditions the office prefers steel H-pile foundations. Design of the piles will require information from soil borings. If soil borings are not provided, the designer should request borings from the Soils Design Section. With ASD the designer should use the friction and end bearing information in the *Foundation Soils Information Chart, Pile Foundation* [BDM 10.2.1.5]. With LFD the designer should use the information in the LRFD Bridge Design Manual [BDM 6.2.7].

Drilled shaft foundations may be used only with permission of the supervising Section Leader. Overhead bridge sign structures typically are designed under the assumption that the foundation between two end posts is continuous and base plates are not subject to relative movement, as would be the case for independent drilled shafts.